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The Influence of Some Adjustment Processes on the Response to Monetary Shocks in SAM

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1 INTRODUCTION

In this paper we use the Bank of Canada's Small Annual Model (SAM) to explore the role of wage and price rigidities in the disinflation process. SAM is a small, theory-based model of the Canadian economy useful for medium- to long-run policy simulation. Its structure is documented in Rose and Selody (1985). The paper focuses on how certain aspects of SAM's wage and price dynamics and expectations formation influence its simulated response to a domestic monetary contraction in the form of a 5 percentage point reduction in the money-growth rate. The experiments are all run using standard SAM conventions for government and central bank decision rules. In particular, the government uses personal direct taxation as the long-run residual source of finance for government activity, and the monetary authority sets the level and growth of the money stock exogenously and does not respond to the endogenous path of the system. Each of these points has important implications for the results.

Consider, first, the financing of government activity. In the short run in SAM, bond sales provide the residual source of finance for government. Thus, in a monetary contraction, where the government loses some real revenue permanently (at least the inflation tax), and where (until prices adjust fully) there is a greater reduction of revenues than expenditures (partly because of a real contraction after the monetary shock), bond issues will tend to increase after the shock. Were this to continue, the interest payments required would necessitate more bond issues such that the implications for the nominal interest rate are unclear. However, using the standard SAM convention that personal direct taxation is the long-run residual source of finance for government activity, taxes move to ensure that the response of the debt-to-GNE ratio is neutral, and so nominal interest rates come down by virtually the exact change in the inflation rate, at least in the long run.

Consider, next, the implications of the behaviour of the monetary authority in SAM. Since the money stock is exogenously set, there is an equilibrium price level, consistent with the long-run real-balance-preference function, to which nominal values must adjust. What is more, when the money-growth rate is reduced, leading to lower nominal interest rates, the level of real balances demanded rises, and this implies a shift

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downward in the price level (in addition to the lower rate of inflation). Two points are important here. By assumption in these experiments the monetary authority does not provide extra nominal balances to offset the level shift in the equilibrium price level. Thus, there is more deflationary pressure on impact than there would be in an alternative world where the level of the money stock was adjusted. Second, since there is a unique final price level, the adjustment path taken is a truly cycle phenomenon. The eventual solution is <u>independent</u> of the path taken. In some models, velocity can change such that the adjustment path of prices influences the final level of prices, and hence influences the average inflation performance over the transition. In other models the real interest rate can change permanently after a monetary shock, and by an amount influenced by the adjustment path of prices. Again, in this case, the final level of nominal variables depends on the path of prices. In SAM, because of the unique equilibrium price level, this is not so. Any delay in price adjustment results in overshooting later as the level equilibrium condition for prices is generated. Faster adjustment does not change the equilibrium price level; it just limits later overshooting and (possible) secondary cycling. How <u>real</u> cycles are affected is one of the main questions addressed by this paper.

In the experiments reported below we concentrate on expectations of inflation and wage and price dynamics. We consider what happens when we change certain aspects of these equations.[1] We characterize fewer or less powerful rigidities as implying a faster short-run adjustment towards equilibrium for the variable in question. In general this is not a bad characterization. However, in a general simultaneous system it is not necessarily true that forcing one market closer to equilibrium, or one price closer to its value in a full solution will make things 'better' elsewhere. Indeed, movements away from equilibrium in one instance may serve to buffer the effects of shocks elsewhere. For example, if a monetary contraction causes aggregate demand to fall (temporarily), and unemployment is created, a faster response of money wages to unemployment, if it resulted in a lower real wage, could further depress consumption and be cycle-magnifying and not cycle-damping. We shall provide several examples below. The point is that moving 'faster' to solve a partial problem (here, excess supply of labour), may exacerbate a general problem (markets are not all clearing).

A related point that arises in SAM is that factors that might bring about faster adjustment to a monetary shock initially, may be sources of increases in disequilibrating effects later. Take, for example, the effect of excess demand on prices. If there is a monetary shock

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1. A complete discussion of all the issues pertinent to assessment of SAM's dynamic response to a monetary shock is beyond the scope of this paper. See Rose and Selody (1985) for a complete discussion of these equations, and in particular Chapter 3 for some partial effects of a monetary shock.

(reduction in the money-growth rate) and real demand is at least temporarily depressed, then an excess-demand term in a price equation will help in moving prices in the right direction in the first few periods. In SAM, where we use the model-based level equilibrium condition as part of the determination of price dynamics, and where price changes are influenced by forward-looking expectations, such excess-demand terms can be viewed as providing a description of how the market responds to surprises and sets up actual changes that help expectations converge onto the new nominal path. Once the initial 'learning' has been accomplished the gap term becomes potentially destabilizing -- something that perpetuates secondary cycling. So higher coefficients (higher responsiveness to excess demand) may be stabilizing in the short run -- bringing inflation down faster -- but destabilizing afterwards -- sources of continuing real disequilibria. In short, a 'gap' is stabilizing only if its sign is the same as the required direction of price movement.[2] As this is not generally so, it is difficult to clearly interpret what more or stronger rigidities mean in terms of parameters in the model.

What we demonstrate can be summarized briefly. Factors that help keep prices and real wages close to their full equilibrium values tend to generate somewhat faster adjustment to nominal shocks but, more importantly, much less severe real disturbances, especially longer-term cycling of real variables. Other influences on wage and price dynamics may assist in generating faster adjustment to monetary shocks initially, but at the cost of greater real cycles later. Expectations formation has a very important effect on the process. The more sluggish are expectations in responding to new conditions, the more important it is that markets themselves generate the necessary adjustments (and pull expectations with them). Conversely, if expectations are fast to respond, rigidities (as represented by limited response to disequilibrium signals in markets) have little effect after the first couple of years.

An important qualification to these considerations is that it is difficult to distinguish between expectations delays and structural rigidities. What we generally think of as expectations delays can be interpreted as delays in perceiving a change in conditions (expectations effects in the behavioural sense), as well as delays in responding to an anticipated change.

The next section of the paper consists of a discussion of the wage and price dynamics in SAM along with expectations formation (section 2). Then we report the results of experiments where we change certain coefficients in the equations leaving expectations formation unaltered (section 3). This is followed by a section where we report the results of experiments where we change those (expectations) equations to introduce

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2. True dynamic stability is more complicated, of course. For example, we could explode with oscillation. Such issues are not of practical concern here, however.

purely backward-looking expectations formation (section 4). A final section provides some concluding observations.

2 SOME ASPECTS OF WAGE AND PRICE DETERMINATION IN SAM

SAM's dynamic equations differ from those in most other models principally in the use of explicit level equilibrium conditions in the adjustment equations. Consider a simplified version of the price dynamics.

$$\begin{aligned} \text{J1D}(\log(P)) = {} & \alpha*\log(PS/PC) \\ & + \beta*\log(SALES/UGPCSS) \\ & + DNPX + \gamma*\log(W/WS) \\ & + \text{other terms.} \end{aligned} \tag{1}$$

The actual rate of change in the price of the domestic non-energy good is determined by the extent of price-level disequilibrium, the extent of excess demand for the product, the extent of disequilibrium of nominal wages, an underlying trend, and other influences that we can ignore here.[3] In the long term, equation (1) becomes a description of a process whereby the level of prices moves to generate the nominal general equilibrium of the model. The equilibrium is characterized by PC, the consumption price, moving to its equilibrium value, PS, determined essentially by the money setting. The equation is for P, but there is direct pass-through to PC via a price index:

$$\log(PC) = \alpha*\log(P) + (1-\alpha)*\log(PM), \tag{2}$$

where PM is the domestic market price of the import good and α is the weight of domestic good consumption in total consumption.

In SAM we think of DNPX as the expected rate of inflation. However, the price-dynamics equation does not represent anyone's conscious choice. It is a market process, a result of demand and supply influences, and it is affected by decisions of many agents. As such, it is sometimes better to think of DNPX as the underlying trend inflation rate. In steady state, expectations will converge on DNPX which, in turn, will converge on a value determined by the monetary authorities through the choice of a money-growth rate. In its most general interpretation, DNPX represents expectations influences and rigidities in the inflation rate (as opposed to rigidities in the price level).

In the standard version of SAM we specify DNPX as follows:

$$DNPX = \alpha*\text{J1L}(\text{J1D}(\log(P))) + (1-\alpha)*(DNHE-DNUBSS). \tag{3}$$

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3. In the experiments here the only other term is a terms-of-trade variable. This term is used mainly to capture extra effects when there are foreign price shocks. Here it captures effects of real exchange rate changes.

To think of this in terms of expectations, we note that in steady state the inflation rate will be the money-growth rate less the real growth rate (presumed independent of inflation) and specify an expectation as a weighted average of all future expected inflation rates, the weights declining exponentially with the distance into the future. Under this interpretation, which we can think of as an average expected inflation rate over the future, a wide variety of assumptions about the path of actual inflation from the current level to the steady-state level produces a result with the form of a simple weighted average of the current and steady-state values.[4] In equation (3) we introduce a one-period delay in the measure of the actual rate of change and some 'learning' about the money-growth rate. DNHE stands for the expected money-growth rate, or more accurately, the private sector's perception of the central bank's chosen growth rate. In the standard version of SAM we measure this as a simple three-period average, including some recognition lag when a change in monetary policy is introduced. The specification of DNHE is arbitrary and part of the maintained hypothesis of any simulation. For fully anticipated monetary shocks we would change the standard specification to remove the recognition lag. For the experiments reported in this paper we use the standard form. Thus, by year 3 the change in the rate of money growth is correctly perceived.

We have presented the argument treating equation (3) as expectations formation. One can, however, give equation (3) a more general interpretation, as simply representing the way the system is affected by the underlying equilibrium condition for rates of change. Lacking an explicit choice theoretic foundation for equation (1), we cannot give a clear interpretation of DNPX nor a clear distinction between delays in expectations response and structural rigidities. Later, we do experiments where we change the equation for DNPX. We talk about this as if it were expectations formation, but the reader would be quite justified in giving it a more general interpretation.

In considering equation (1) the reader might be misled into thinking that since there are mechanisms to remove real excess demand and so on, and since once the level of PC has adjusted to PS, P can rise at any arbitrary DNPX. In other words, actual inflation is whatever is expected, in a causal sense. This is not so. Since desired real balances are essentially independent of nominal money, the level of PC must adjust to set <u>real</u> balances at the desired level.[5] If DNPX were greater, say, than the equilibrium inflation rate (given by the exogenous money-growth rate less the real growth rate) and if PC were initially at PS then the higher-than-equilibrium inflation rate for P would force PC to rise faster than PS (through identity (2)). As a result, the level equilibrium gap

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4. See Rose and Selody (1985), Chapter 4, for details.

5. For more details on the derivation of PS and the implications of real-balance disequilibrium see Rose and Selody (1985), Chapter 3.

would open and serve to moderate the actual inflation rate. Expectations would gradually adjust such that DNPX moved to the 'correct' value. If expectations, or whatever is behind DNPX, is specified to be totally exogenous, then unless the monetary authority treats it as a target and sets money growth accordingly, the model has no consistent solution.

Consider now the wage equation in SAM, again in a somewhat simplified form to clarify the exposition:[6]

$$\text{J1D}(\log(W/P)) = \alpha + \beta*\log((WS/PS)/(W/PC)) + \gamma*(\text{RNAT-RNU}) + \theta*(\text{DNPE-DNP}). \qquad (4)$$

As was the case in equation (1) the adjustment equation for the real wage exploits the model's equilibrium real wage. From the perspective of the suppliers of labour we can write this wage as WS/PS.[7] If the current real wage differs from this equilibrium wage, equation (4) specifies that the rate of change of the real wage is altered such that the real wage converges towards the required equilibrium value. As was the case for price dynamics, we view this as a market process, not reflecting any agent's direct decision or even any explicit model of bargaining. It is simply an expression of the tendency of markets to generate a general equilibrium. This tendency is specified to play a role even when it is in conflict with the current state of excess demand in the labour market itself. The level of excess demand in the labour market, as measured by RNAT-RNU, has an independent effect, but that effect is conditioned by the state of general equilibrium as represented by the wage gap. Where there is excess demand for labour and the wage is too low, then both the partial and general equilibrium forces will be in synchronization and there will be a combined upward pressure on the real wage. If there is excess demand for labour, but the wage is already too high (reflecting response to a previous sequence of excess demand, say), then the upward pressure will be blunted and at a certain point reversed by the equilibrating force of general equilibrium.

The final term in equation (4) represents the effect of expectations (of inflation) errors. In an expectations-augmented Phillips curve, nominal wages are specified to rise according to expectations of inflation. If expectations of inflation are wrong, too high say, the nominal wage rises more than warranted by actual price changes, and the real wage rises temporarily. In SAM, this type of effect is introduced directy as a partial pass-through of expectations <u>errors</u> into the real wage.

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6. The equation in the model is more complex in that it has the trend growth linked to trend productivity growth. It also has a more complex structure for expectations errors that introduces a separate role for consumer prices (and hence import prices) in influencing the real wage in a disequilibrium sense.

7. For a derivation of the equilibrium real wage in SAM see Armstrong, RM-83-38. For a more complete discussion of the use of this concept in the model see Rose and Selody (1985), Chapter 3 and 4.

It is perhaps worth repeating here a point made in general terms in section 1 that, aside from trend productivity and the wage gap itself, all other sources of movement in the real wage are likely to be sources of disequilibrating movements in the real wage and hence causes of continuing real cycles in the model as a whole. In the first few periods after a monetary shock, introduced into a state of equilibrium, the unemployment gap may well coincide with the real wage gap and hence be stabilizing. It may, in fact, act to fight against distortions coming from expectations errors. As simulation time passes, however, the unemployment gap is likely to become a source of continued disequilibrium. On this point SAM is quite different from many other models. For example, in RDXF the process of adjustment focuses on and requires this gap to drive the system. Monetary policy works by opening a gap. If there is no gap, nominal variables cannot adjust to a new nominal growth path.[8] The key point is that this considerably alters the interpretation of changes in certain coefficients in the model. In RDXF, and many other models, a higher coefficient on the unemployment gap would clearly mean a system more responsive to monetary shocks, a system with faster pass-through of monetary changes to wages and prices. In SAM, however, the parallel might be a higher coefficient on the basic equilibrating force as represented by the wage gap. To raise the coefficient on the unemployment gap might produce movement towards equilibrium initially (if, for example, it nullified some of the effect of expectations errors). But the result would likely soon be a less flexible system that has a reduced tendency to converge on the new nominal growth path.

Because of the use of explicit level-equilibrium conditions in many of the dynamic adjustment equations in SAM, we interpret all other terms in such equations as capturing short-run dynamic influences, things that operate in the first few periods after a shock is introduced. They represent confusions about recognizing the exact nature of shocks and other sources of inertia and short-run feedback. Once the shock has been operative for a certain length of time, however, the nature of adjustment changes. To reflect this change, the influence of these terms is reduced. Examples of the procedures used to achieve this reduced influence will be provided in the next section.

3 THE MODEL WITH FORWARD-LOOKING INFLATION EXPECTATIONS

3.1 The Base Case for Comparisons

To provide a base with which to compare the experiments that follow, we first consider some of the salient features of the shock-minus-control

8. In some experiments extra effects are introduced in RDXF through expectations. But the standard model does not contain this link. Furthermore, the direct link through excess demand to price inflation to expectations is weak. Thus, the gap in the wage equation is central. Money-wage growth comes down because of the gap, and this feeds into price inflation through a cost-markup price equation.

results for a -5% per annum money-growth shock. We use as our standard point of departure the 'rational equilibrium' version of SAM, where expectations adjust fairly rapidly to shocks and where there are strong equilibrating forces in markets. We also present the results of the same experiment with movements in wages and prices held at equilibrium in the sense that they move in proportion to changes in the equilibrium values, shock minus control. This provides us with an idea as to how much of the 'real' consequences of a monetary shock can be directly attributed to wage and price disequilibrium in SAM.

The simulations were performed for the period 1983-99. In describing the results we generally refer to the years using simulation time, not calendar time (i.e., year 1 rather than 1983).

As noted in the previous section, when we simulate SAM over long periods of future time, we sometimes change certain aspects of the model's estimated dynamics, essentially increasing speeds of adjustment towards full equilibrium as simulation time proceeds. We do this because we think the parameters of the model underestimate the economy's true speed of adjustment to a general equilibrium. For these experiments the model is left unchanged for the first three years of simulation. This is the notional period over which learning about the shock occurs and disequilibrium cycles are initiated. After year 3 certain things are changed. For example, expectations of inflation (where money growth has changed, such as in the experiments described here) are gradually moved away from a concentration on the current outcome of inflation towards a heavier weight on the steady-state value to which the model is tending. At the same time we begin to increase some of the coefficients that tend to move the model back to equilibrium and reduce other coefficients that tend to prolong cycles. Some examples are: the coefficient that tends to pull the price level towards its equilibrium value is increased in year 4; the speeds of adjustment of factors of production towards equilibrium are increased in year 6; the term that induces movements of the real wage owing to inflation-expectations errors is removed after year 6, while the similar effect from the unemployment gap is gradually reduced to zero over years 3 to 8. Thus, from year 8 the real wage moves towards its full-equilibrium value according to an enhanced partial-adjustment process.[9]

Figures 3.1.1 to 3.1.6 are graphic representations of the results for a few variables of interest. The price and output results are for the non-energy private sector good. The results for total private output and for gross domestic output (i.e., adding government wage expenditures) are similar and we prefer to report our directly modelled aggregates. The real wage is reported using the consumption price as a deflator. In other

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9. We are still in the process of documenting real/financial linkages in SAM, and just beginning a detailed consideration of the model's dynamic properties. The particular conventions used to modify the dynamics here are preliminary.

words, it is the real wage from the perspective of the household suppliers of labour. The results for the real wage from the perspective of firms can be a bit different, especially in the first few periods, owing to changes in relative prices.

Consider, first, the equilibrium run, labelled W&P EQUILIBRIUM on the figures. Note that eliminating wage and price disequilibrium reduces, but does not remove, the real consequences of a monetary growth shock. There is still a real contraction. This can be traced to a trade cycle and some movement in government variables. The latter results from difficulties in measuring endogenously the required change in steady-state tax rates. Our measure of the required tax rate overshoots a bit and causes the notional equilibrium after-tax real wages to decline too much, which in turn leads to too great a decline in measured steady-state labour supply and potential output. This feeds into the demand system (through desired inventories and consumption) and causes a real contraction that is unwarranted, in the sense that if we had a better ex ante measure of the required tax change, the cycle effect would not develop. The cut in money growth requires some tax increase and potential output does fall, but only by about 0.2% and not the close to 1.0% we get in year 4.

The major source of the real output effect of the money-growth shock comes from a foreign-trade effect.[10] We present the results here to make two tentative points. First, it is not necessarily the case that real consequences of monetary shocks come only from wage and price disequilibria. Second, in interpreting the magnitude of real effects reported in the rest of the paper, the reader should keep in mind that a substantial temporary but long-lasting real cycle exists in the model with no rigidities in prices and wage formation.

Despite these qualifications the comparison does permit us to see some considerable 'gains' in having wages and prices stay closer to equilibrium. The rate of price increase comes down faster, overshoots less and stabilizes more quickly than in the base case. The real output contraction is markedly smaller, as is the rise in unemployment. The interest rate and the exchange rate converge more rapidly to the new nominal path.

Consider now the base-case results. In the first year inflation comes down only 1 percentage point. However, over the next two years measured inflation rates fall 3.3 and 5.7 percentage points below control, respectively. Thus, overshooting on inflation begins in year 3. This stabilizes the maximum price-level disequilibrium at about 4.4 percentage points above control. After that inflation remains in 'overshoot' for

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10. Subsequent experiments have enabled us to identify the source of the cycle as being largely an inappropriate trade cycle. We have now modified the model such that much of the contraction shown in the W&P EQUILIBRIUM experiment would be eliminated. As a result the absolute level of the shock-minus-control results in this paper may be overstated. The relative comparisons used in our analysis, however, should be reliable.

three more years and then converges rapidly to equilibrium, with cycles. In this version of SAM, nominal interest rates do not rise even in the first period of monetary contraction. However, they are down less than 0.3% and both ex post and ex ante real rates rise. We shall see later that with a bit less rationality and less powerful equilibrating forces, SAM does generate an increase in nominal interest rates in the first couple of years after the shock. Here, however, nominal rates fall starting from year 1 and slightly overshoot the -5 percentage points value in year 5 of the simulation. By the end of the simulation, nominal rates are down about 4.6 percentage points and inflation 4.9 percentage points, leaving real rates up by about 0.3 percentage points. The long slow process of moving bond stocks back to their equilibrium levels (initially bonds go up to replace the money finance lost and the initially higher real interest payments on government debt[11]) is not complete after 17 years, but nearly so.

The exchange rate appreciates by 0.4% in the first year -- less than the change in prices -- as expectations take some time to adjust. Thereafter, the results for the rate of change of PFX look like a smoothed version of the domestic price-change movements. The overshoot is only about half as big, for example.

Nominal wages initially rise above equilibrium, (i.e., do not fall one for one with the equilibrium wage) but largely because prices do. Real wages are not much changed. It is only later that secondary cycling in real wages develops. The initial real wage neutrality is despite a fairly powerful term to let expectations errors change real wages. The point is that while expectations do not follow money down immediately they quite accurately reflect what actually happens to prices. There are no sizeable errors in the usual sense -- only confusion and disequilibrium.

A disequilibrium state, once it develops, is extended by the inventory-adjustment process. Initially, inventories buffer a significant proportion of the demand slump. By year 6 inventory stocks are about 8% above desired (relative to control). The stock disequilibrium is then reversed over the next four years and there is some overshooting that leads to small secondary and tertiary real cycling in the last part of the simulation. Here too, the overshoot in the measure of potential output introduces extra real cycling because desired inventories are based on potential sales and so part of the actual demand slump comes from a desired inventory cycle.

In summary, in our base case the money-growth reductions of 5 percentage points lead to inflation coming down by a similar amount over three years, but with some overshooting thereafter. Interest rates come

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11. The government financing requirement rises above control for three years, despite the falling prices, and then declines rapidly. Tax rates rise sharply over years 3 to 5 (peaking at 4.3 points above control in year 5) and remain high for another three to four years before beginning a slow decline to an equilibrium increase of about 1 percentage point.

down over five years, and a real contraction is generated that troughs at about the end of year 5. After ten years everything is pretty well on track, but some cycling persists to the end. Expectations formation, while not Muth-rational in the strict sense, is sensitive to the shock and not much removed from rationality.

3.2 The Effects of the Adjustment Processes in the Wage Equation

3.2.1 The influence of equilibrating forces

One of the most obvious differences between SAM's adjustment equation for wages and the standard expectations-augmented Phillips curve, is the use of the model-based equilibrium wage to condition the disequilibrium process. The further wages deviate from equilibrium, the more powerful (relatively) becomes this equilibrating force. As such, it seemed a natural place to begin to see what effect this term had on the response to a monetary contraction. But as noted in section 3.1, no significant real wage disequilibrium is generated, despite the nominal wage disequilibrium and the unemployment. As might be expected then, changing the coefficient on this term has virtually no effect on the results. We reduced the coefficient from 0.2 to 0.05 for the first six years of the simulation. The inflation and interest rate paths are virtually unaffected as is the first part of the real cycle. The only noteworthy changes are larger and longer-lasting real disequilibria. Beginning about year 5, output is lower than the base case and unemployment is higher. The peak differentials occur in the mid-1990s, at about 1.2 percentage points for output and 0.6 percentage points for unemployment. However, these differences seem very small when compared with the similarities of the two runs. The profile of price changes is virtually identical, for example. All that happens, essentially, is that with weak equilibrating forces for the real wage, the minor secondary cycling of output is prolonged.

3.2.2 Combined changes to wage adjustment

To extend the above experiment we added changes to the coefficients on inflation-expectations errors (an increase) and on the unemployment gap (both an increase and a decrease were tried). A larger coefficient on expectations errors will tend to increase the real wage immediately after a negative monetary shock. This will be offset by a rise in the coefficient on the unemployment gap and reinforced by a decrease in this coefficient. We can certainly see this effect in the results. The real wage does not fall as much in the runs with a low coefficient on the unemployment gap. As a result, consumption does not fall as much initially and the output effects of the monetary contraction are correspondingly smaller initially. Moreover, with a small coefficient on the unemployment gap, the real cycle is less severe and output comes back to control much faster. This illustrates well our point that the

unemployment term can have a destabilizing effect after the first few periods.

But what of inflation? The higher wage and smaller declines in output in the short run would, in some models, lead to worse performance for inflation. We do not observe this here. With the base-case price equation there is too much independent 'rationality' in expectations and too weak a pass-through of the wage and output effects to change the profile of prices very substantially. Any latent delay in the adjustment of prices from the smaller output gap appears to be almost offset by stronger effects from the price gap.[12] The results for prices and interest rates are so close to the base case that we shall not bother to provide figures for these variables here. We shall return to these points in a later section where we consider a world with more rigidities in price adjustment and in expectations.

The figures we provide are designed to show the real consequences of changing the coefficient on different terms in the real-wage-adjustment process. To highlight the point we add an extra dimension to the runs. In one set we leave the basic equilibrating force (via the wage-gap term) lower throughout the experiment. In another set we lower these forces initially, but return them to the base-case level in year 7. As the figures make very clear, this has a marked influence on the length and size of the real cycle, most notably when we have a higher coefficient on the unemployment gap.

We report results for the real wage (using the consumption price index as a deflator), consumption, non-energy output and unemployment. Note the extreme real consequences of a higher coefficient on the unemployment gap combined with lower basic equilibrating forces as represented by the coefficient on the real wage gap. The lower coefficient on the unemployment gap produces much less extreme real response. This is a good illustration of our basic point about such terms being destabilizing in the longer run in SAM. Finally, in both cases, returning the basic equilibrating forces to base-case levels from year 7 brings the solution back towards control (and equilibrium), although in the case of a high unemployment gap coefficient we are still some way away from control after 17 years.

3.3 The Effects of the Adjustment Processes in the Price Equation

3.3.1 The influence of equilibrating forces

We begin our consideration of the effects of variation in dynamics in the price equation with the term AP50* log (PS/PC). Our base-case value

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12. In the base case there is no wage pass-through, so this term has no effect. This experiment would have been more interesting had we changed our base case to allow for wage pass-through, but we did not do so. Experiments reported later take this point up again in the context of a world with both more price rigidity and less rationality in expectations.

for AP50 is 0.3. Here we reduce it to 0.1 and hold everything else unchanged. We interpret this as representing an increase in rigidities or other factors that lead to weaker ties between actual prices and their full equilibrium values.

The results, as shown in the accompanying charts, are slower adjustment of inflation and interest rates and sharper and more prolonged real consequences. The delayed response of prices to the monetary change results in a larger and stronger overshooting of inflation. The difference in real effects is largest in year 3 when it is almost 1 percentage point for output and 0.5 percentage points for unemployment.

3.3.2 A combined experiment: 3.3.1 plus higher sensitivity to wage disequilibrium and lower sensitivity to output market excess demand

We now turn to an experiment where we retain the lower basic equilibrating forces of 3.3.1 and add to that two other sources of slower adjustment.

Recall that in SAM, with money exogenous, the final nominal levels of variables are independent of the path taken in a shock. Any feature that tends to move prices independently of their money-determined equilibrium values is potentially destabilizing. In particular, since money wages tend to respond only with some delay to the monetary contraction, allowing more feedback from wages to prices tends to delay the reduction of inflation. Here we add a 10% pass-through of disequilibrium wage movements to prices.

The response of prices to the excess supply in the product market tends to aid in moving prices 'appropriately' in response to a money shock in the first few years. The dampening effect this excess supply has on prices in SAM provides an important source of the short-run downward adjustment that facilitates the adjustment of expectations and the re-establishment of real-side equilibrium. To simulate a world with more price resistance we lower the output-gap effect. Note that, while this may slow down the early adjustment of prices, in the longer run it contributes to stability because when inflation eventually overshoots there is still excess supply, so a higher coefficient would then be destabilizing. This contradiction between the short- and long-run implications of a particular structure is common in SAM's disequilibrium-dynamics equations. It is for this reason that we shut off or gradually remove the cycle-generation terms as simulation proceeds.

We report the joint effect of the three changes in the accompanying figures. We also did the experiments individually. We found that the joint effect of the changes is much greater than the individual effects or the simple combination of the individual effects.

In the first three years the adjustment of inflation is cut by more than half. It now takes until year 4 before the rate of price change is

5 percentage points less than control. Consequently, overshooting is greater and delayed. From year 10, however, the inflation profiles are very similar. Despite the delaying effects introduced, the basic rationality of expectations provides for the return to equilibrium.

In a similar manner, interest rate reductions are delayed. Here, however, there appears only to be delay and no parallel overshooting. Indeed, the path of interest rates is more stable.

On the real side the initial (year 1) effects are not too much different, but the next few years produce a sharper and longer-lasting contraction. Unemployment rises by more than twice as much as in the base case, peaking at 3.0 percentage points above control in year 4. Output falls by relatively similar amounts in the first years, and larger secondary cycling is set in motion. The cycles at the end of the simulation (where the shock-minus-control results cross zero) are not found to the same extent in any of the individual runs. The reason for the extra boomlet seems to be partly a delayed inventory recovery (the initial excess supply is deeper and longer lasting) and partly a delayed investment recovery (the initial effects on the capital stock are larger and more recovery is required to get back to desired levels).

4. THE EFFECTS OF EXPECTATIONS FORMATION

4.1 Reformulation of Expectations

In SAM, forward-looking expectations are a feature of all parts of the standard model. In this section we look at the role of inflation expectations in conditioning the way SAM produces response to a monetary shock. We do so as follows. We specify new arbitrary expectations-formation formulas, using weighted averages of two lags on the rate of price change, with a weight of 0.7 on the first lag and 0.3 on the second lag:

$$DNPX = .7\ J1L(DNP) + .3\ J2L(DNP).$$

Note that this change roughly switches the forward-looking weight on money growth to a second lag in the backward-looking distributed lag. We introduce this change in the form of shock-minus-control effects only.

We present results for several experiments with the revised expectations. First, we look at the price effects of the change by introducing only this change to the base case. We then look at two combined experiments. We begin with the effect of the combined changes to the price equation discussed in section 3.3. To this we add the changes to the unemployment gap and inflation expectations terms in the wage equation, to see whether in the modified, less rational, more-rigid, price world the wage process has a more substantial effect on the price process. Recall from section 3.2 that, in the base case, changes in the

wage adjustment process alter real variables but have virtually no effect on the price-adjustment path.

4.2 The Effects of Expectations Formation in the Basic Model

The results of the experiment in which we change only expectations formation are labelled EXPECTATIONS in the accompanying charts. In the first 3 years, the effects on inflation are quite similar to those when we reduced the basic equilibrating forces in the equation (labelled EQUILIBRIUM here), somewhat slower than in the base case, but not hugely different. Despite the potential for expectations errors, the basic equilibrating forces bring inflation down and prevent expectations errors from seriously distorting the price-formation process.

The effects on other variables are more dramatic. The initial inertia in expectations leads to two years of increases in nominal interest rates, relative to control, before the decline begins. Moreover, the secondary cycling in interest rates is somewhat more pronounced. The real effects are smaller in the first few years, but build up to larger effects with greater secondary cycling. The reasons are easy to understand. The revision to expectations causes wages to be higher initially (greater effect from inflation-expectations errors) and so consumption does not fall as much. Later, however, since inflation does not stabilize as quickly, expectations errors persist and cause wages to stay away from equilibrium for longer and by larger amounts. As a result real output effects are prolonged, relative to both the base case (where expectations and actual inflation converge relatively rapidly to a steady-state path) and to the case where we simply reduce the equilibrating force. While for the latter comparison we have no way of knowing what notionally equivalent changes might be, it is clear that backward-looking expectations would tend to prolong the cycles inherent in SAM because of the overshooting associated with the price-level equilibrium condition.

4.3 Combined Changes to the Price Equation

In section 3.3 we described the results of making three changes simultaneously to parameters in the price equation, while maintaining the base-case model of expectations formation. We attempted to repeat the exact same set of changes with the modified backward-looking inflation expectations. We found that under these combined changes the model generates very large and long-lasting cycles. Although the model is technically stable and only in a long-cycle mode, we are nowhere near equilibrium after 17 years. For example, after rebounding from the initial contraction, the model generates a substantial boom towards the end; unemployment is 4 percentage points below control in year 17. Evidently, if we remove both the basic equilibrating force and the

forward-looking expectations, SAM becomes a very different model. As there is little point in reporting such an extreme solution, we modify the experiment slightly. Instead of reducing the coefficient on the price gap from 0.3 to 0.1 (as in section 3) we now lower it to 0.2.

With this change there is sufficient equilibrating force in the price equation to produce a clearly converging solution. In the charts we present the base case, the experiment with only expectations changed (EXPECTATIONS), and the experiment where we change the three dynamics coefficients (EXPLUSP), plus two other experiments to be discussed later. In comparing the EXPLUSP and EXPECTATIONS results we see that the rate of price change declines more slowly when we add rigidities to the price dynamics. Overshooting does not begin until year 5 (and is consequently larger). Interest rates do not begin to decline until year 4 and after that they cycle in a more pronounced fashion. The output and unemployment effects are a bit larger initially, but very much larger later as a noteworthy secondary cycle is set in motion. The peak effects are larger and delayed several years and a fairly strong excess demand phase is set up in the last part of the simulation.

Consider, finally, the addition of changes to wage dynamics to the EXPLUSP experiment. We increase the coefficient on the inflation-expectations errors and we increase (COMBINED1) and decrease (COMBINED2) the coefficient on the unemployment gap. The changes are exactly the same as those reported in section 3.2 for the independent experiments on the wage equation. Note, however, that we do not change the parameter on the wage gap.

First, the real wage. The higher unemployment-gap coefficient has a marked effect -- the real wage is much reduced everywhere. With the lower gap coefficient the upward pressure on wages from the expectations errors comes through; real wages fall by less than any other case for the first 4 years, and the later adjustment is relatively modest (a delayed EXPLUSP profile). For real output the differences are similar, qualitatively, with COMBINED2 generating much greater cycling, but the proportionate differences are much smaller than for the real wage itself. Again, COMBINED2 and EXPLUSP are quite similar, especially in the last half of the simulation. For prices and interest rates, the main question is can we see any effects from the wage equation changes? The answer is yes, but they are fairly small. As for EXPLUSP, the combined experiments, relative to the base case have much slower nominal adjustment. Relative to EXPLUSP, however, the changes are small. COMBINED2, with a lower unemployment-gap coefficient, generates the slowest initial decline in prices and the largest temporary increase in nominal rates. After year 3 the differences between COMBINED1 and COMBINED2 become more pronounced but remain small relative to the difference between either and the base case. A higher unemployment effect on wages does indeed bring inflation down faster (the maximum difference between COMBINED1 and COMBINED2 is 1 percentage point in year 6). This statement, however, is only valid

relative to EXPLUSP, that is, a world with expectations delays and other distortions.

5 CONCLUDING OBSERVATIONS

Given the much greater differences between the base case and any of the three distortions runs than among the distortions runs themselves, we can say that in SAM the greatest 'gains' in speeding a nominal adjustment and in limiting real effects of monetary changes come in improving information processing. Making markets respond more to partial disequilibrium signals may help a bit, in the short run, but may also cause greater problems in the medium to long run when the partial signals become destabilizing. Furthermore, what gains may be made along this line are quantitatively small, compared with those available when economic agents correctly perceive policy changes and their consequences and form expectations accordingly. In practical terms, this type of result suggests that great emphasis should be placed on a clear understanding of the goals and practice of policy, especially at times when a change in policy is being implemented. If we assume that the policy makers have special insights as to the nature of equilibria, then the results might also suggest that gains could be made if such information were made available and debated publicly. Because of the lack of a clear interpretation of the meaning of changing coefficients in the SAM equations considered here, and because of the ambiguity concerning the role of forward-looking expectations in these equations (i.e., the point that expectations may contain an element of structural rigidity), one can draw no hard conclusions from these experiments. It is at least suggested, however, that problems concerning the real consequences of monetary shocks may not arise mainly, as is often assumed, because markets do not respond enough to partial signals of disequilibrium.

FIGURE-3.1.1

RATE OF PRICE CHANGE
(SHOCK-CONTROL)

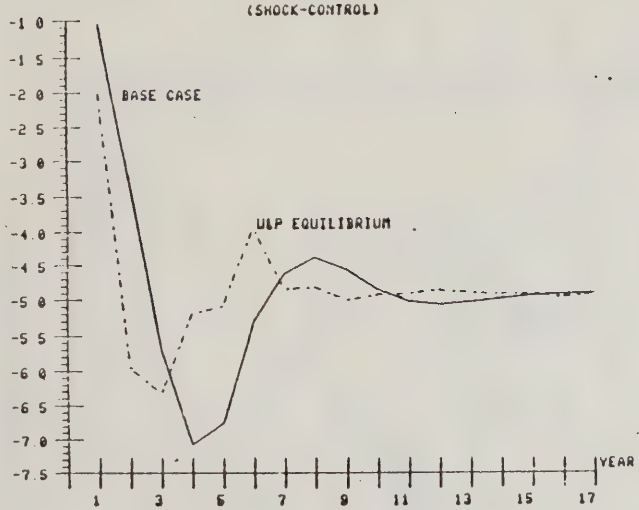


FIGURE-3.1.2

NON-ENERGY OUTPUT
(% SHOCK-CONTROL)

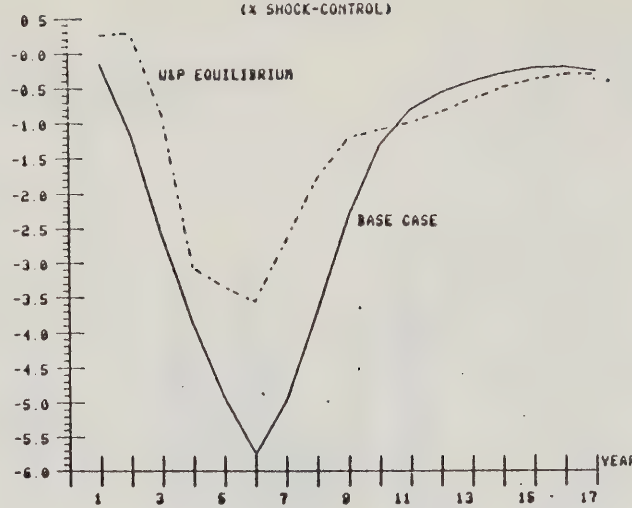


FIGURE-3.1.3

RATE OF CHANGE OF EXCHANGE RATE
(SHOCK-CONTROL)

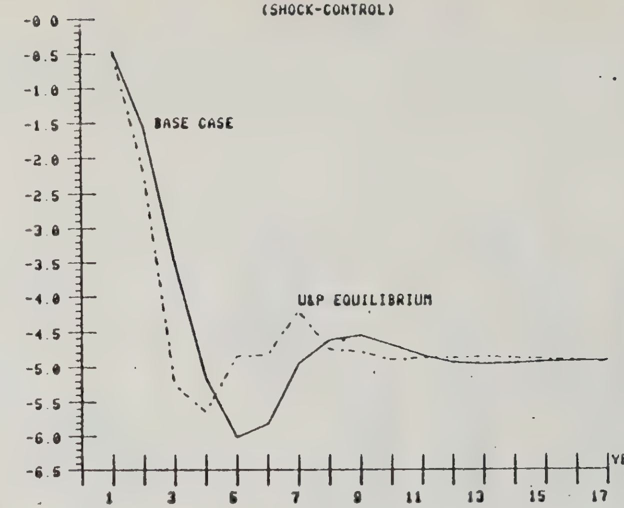


FIGURE-3.1.4

UNEMPLOYMENT RATE
(SHOCK-CONTROL)

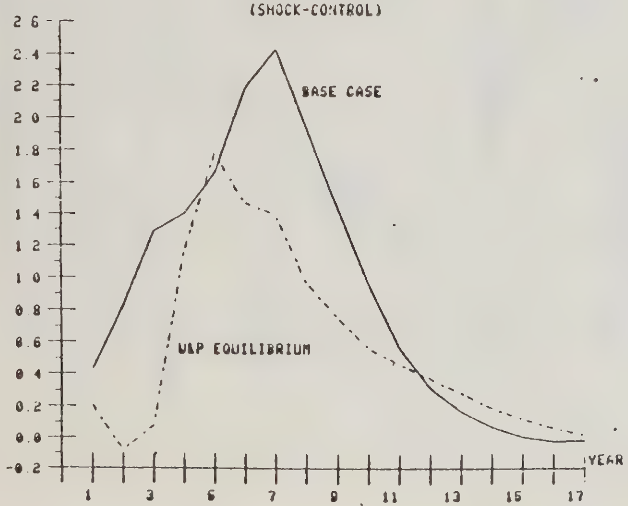


FIGURE-3.1.5

GOVERNMENT BOND RATE
(SHOCK-CONTROL)

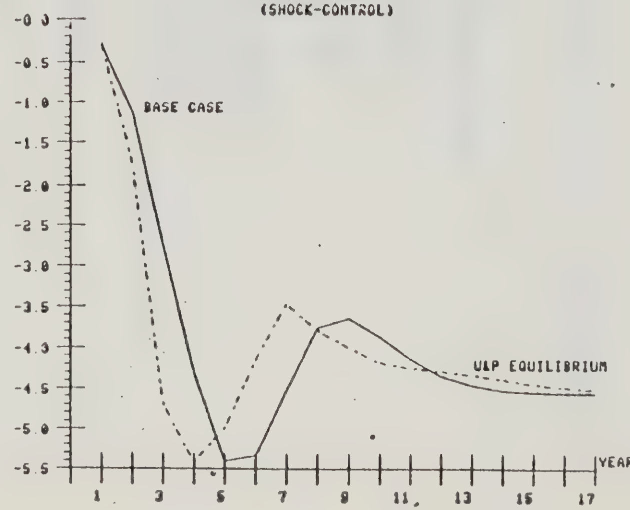


FIGURE-3.1.6

REAL WAGE (CONSUMPTION DEFLATOR)
(% SHOCK-CONTROL)

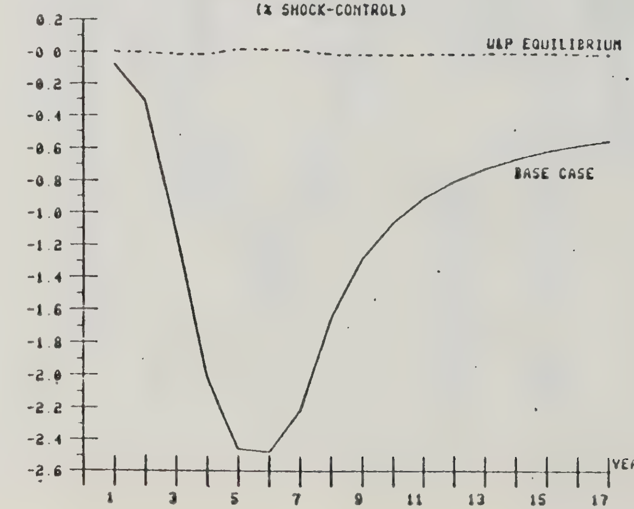
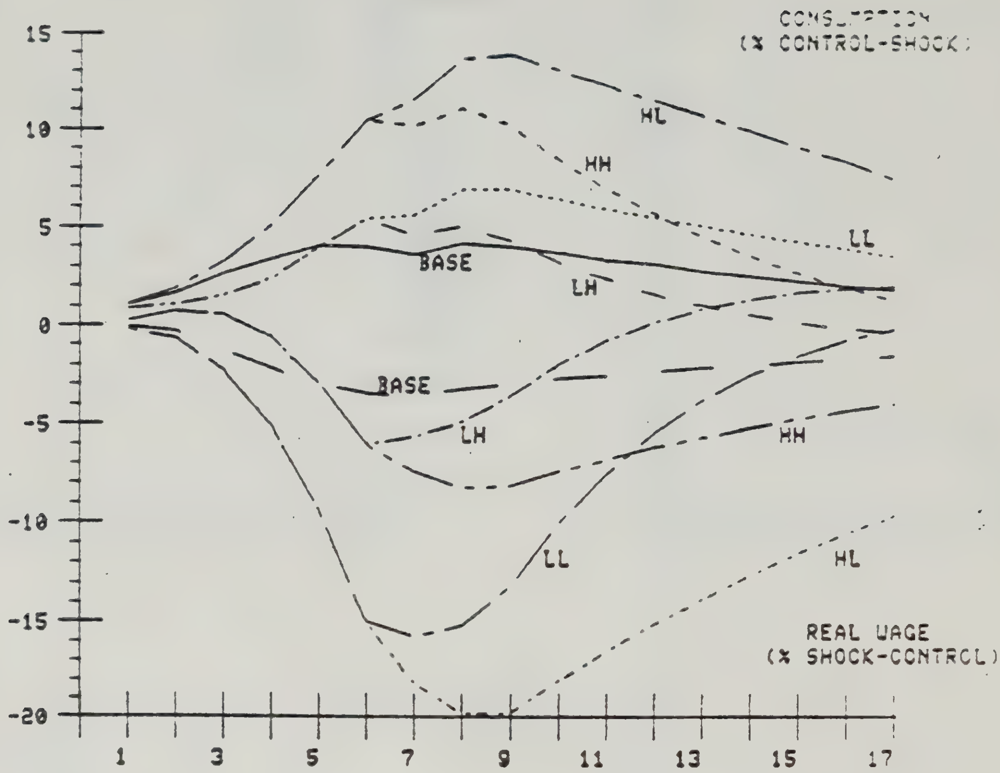


FIGURE 3.2.1



BASE: BASE CASE

HH: HIGH UNEMPLOYMENT GAP COEFFICIENT
HIGH EQUILIBRATING FORCE FROM YEAR 7

HL: HIGH UNEMPLOYMENT GAP COEFFICIENT
LOW EQUILIBRATING FORCE

LL: LOW UNEMPLOYMENT GAP COEFFICIENT
LOW EQUILIBRATING FORCE

LH: LOW UNEMPLOYMENT GAP COEFFICIENT
HIGH EQUILIBRATING FORCE FROM YEAR 7

FIGURE 3.2.2

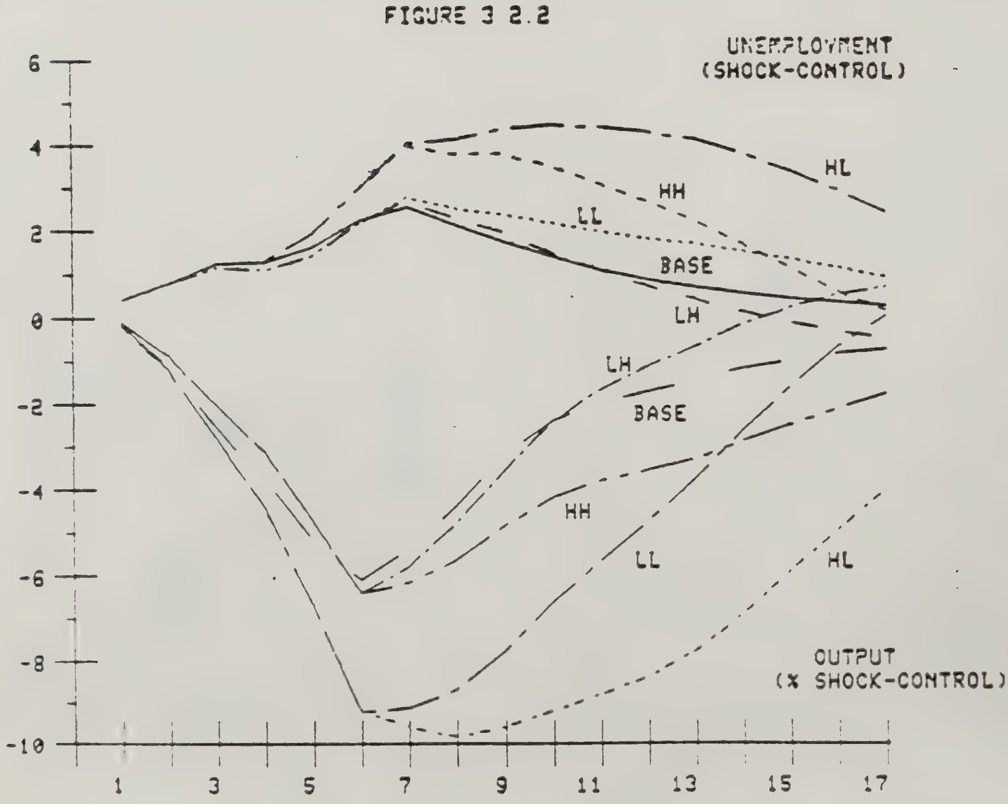


FIGURE-3.3.1

RATE OF PRICE CHANGE (SHOCK-CONTROL)
GOVERNMENT BOND RATE (CONTROL-SHOCK)

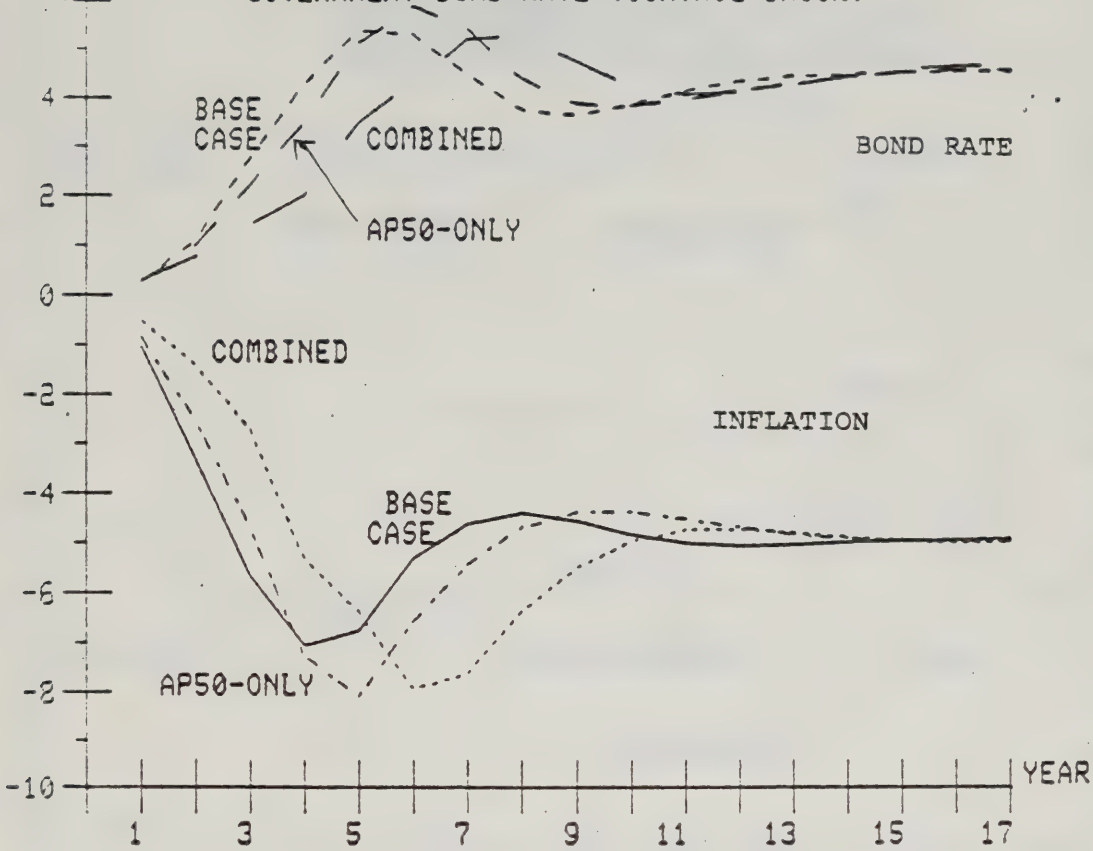


FIGURE-3.3.2

UNEMPLOYMENT RATE (SHOCK-CONTROL)
AND OUTPUT (% SHOCK-CONTROL)

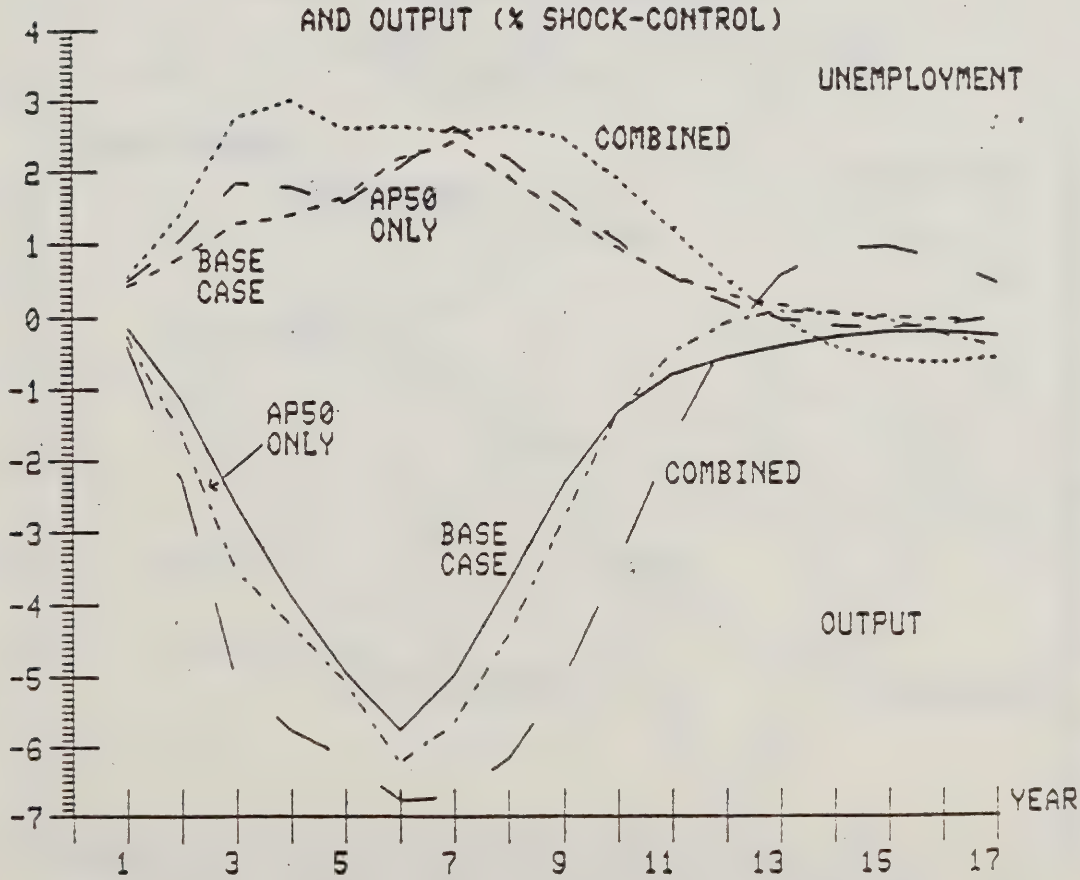


FIGURE-4.2.1

RATE OF PRICE CHANGE (SHOCK-CONTROL)
GOVERNMENT BOND RATE (CONTROL-SHOCK)

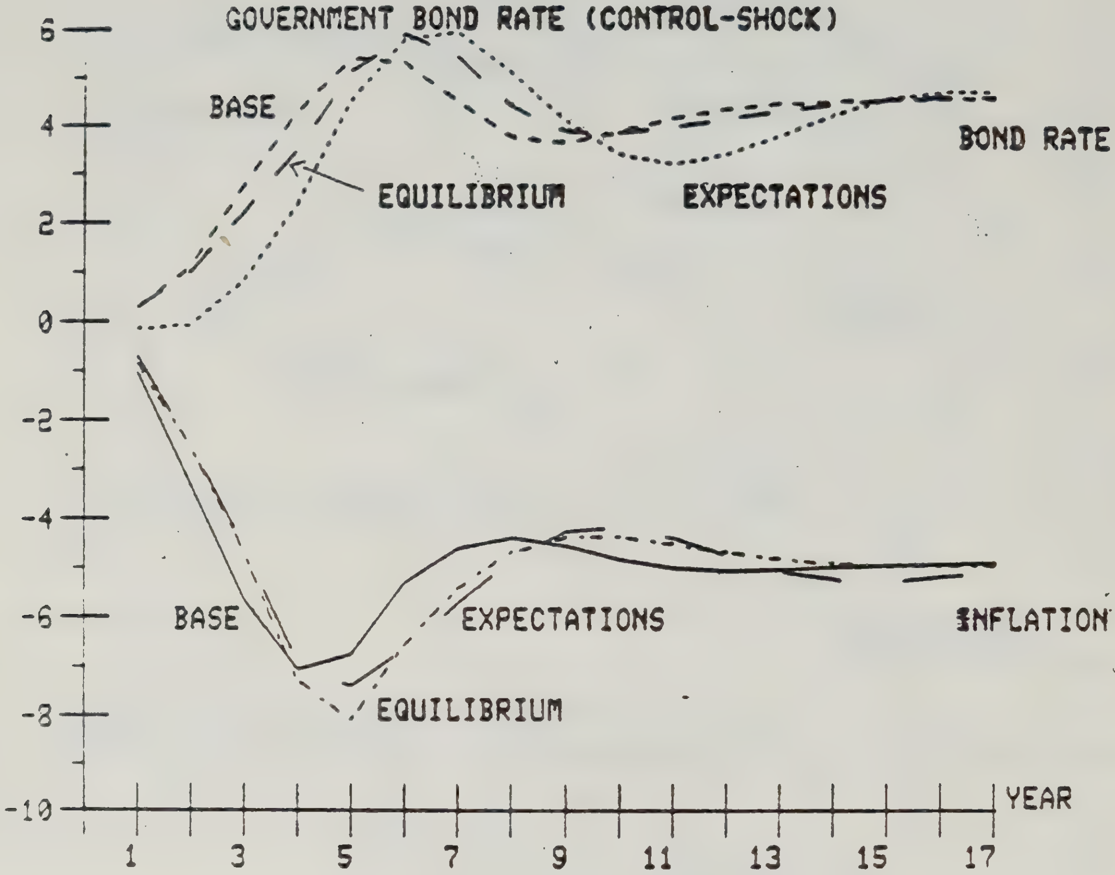


FIGURE-4.2.2

UNEMPLOYMENT RATE (SHOCK-CONTROL)
AND OUTPUT (% SHOCK-CONTROL)

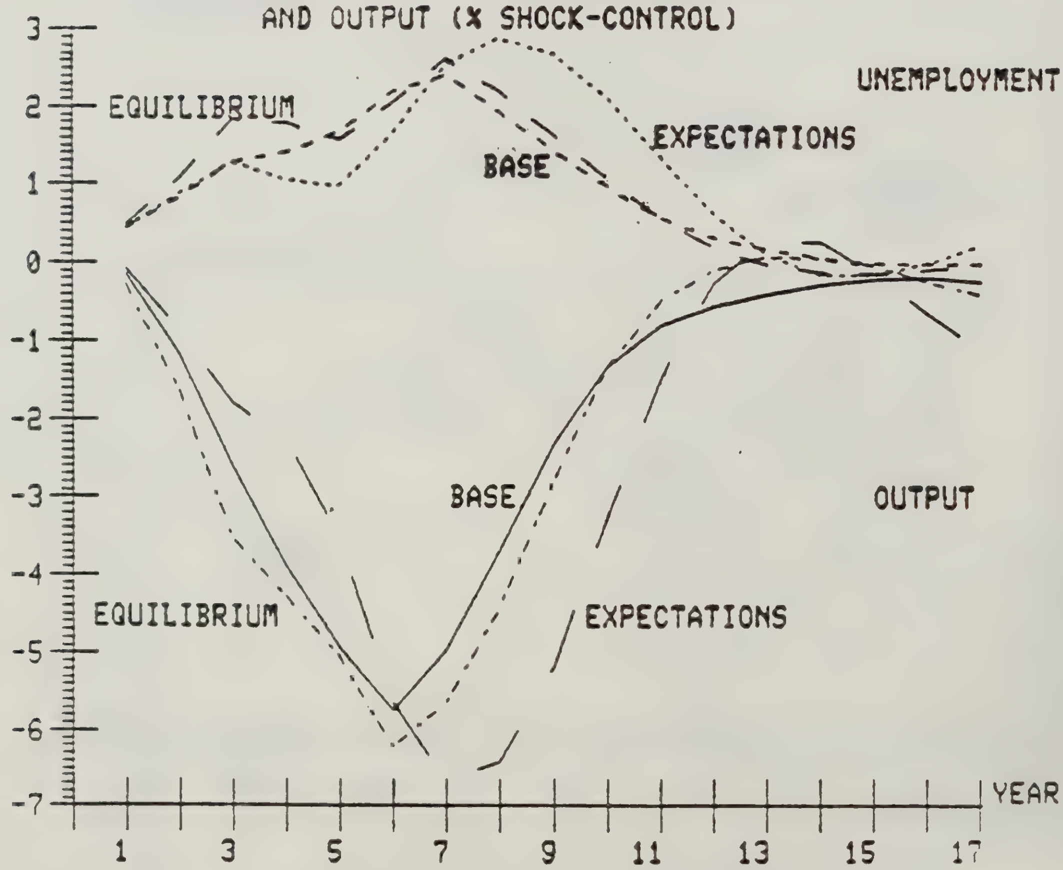


FIGURE 4.3.1

RATE OF PRICE CHANGE
(SHOCK-CONTROL)

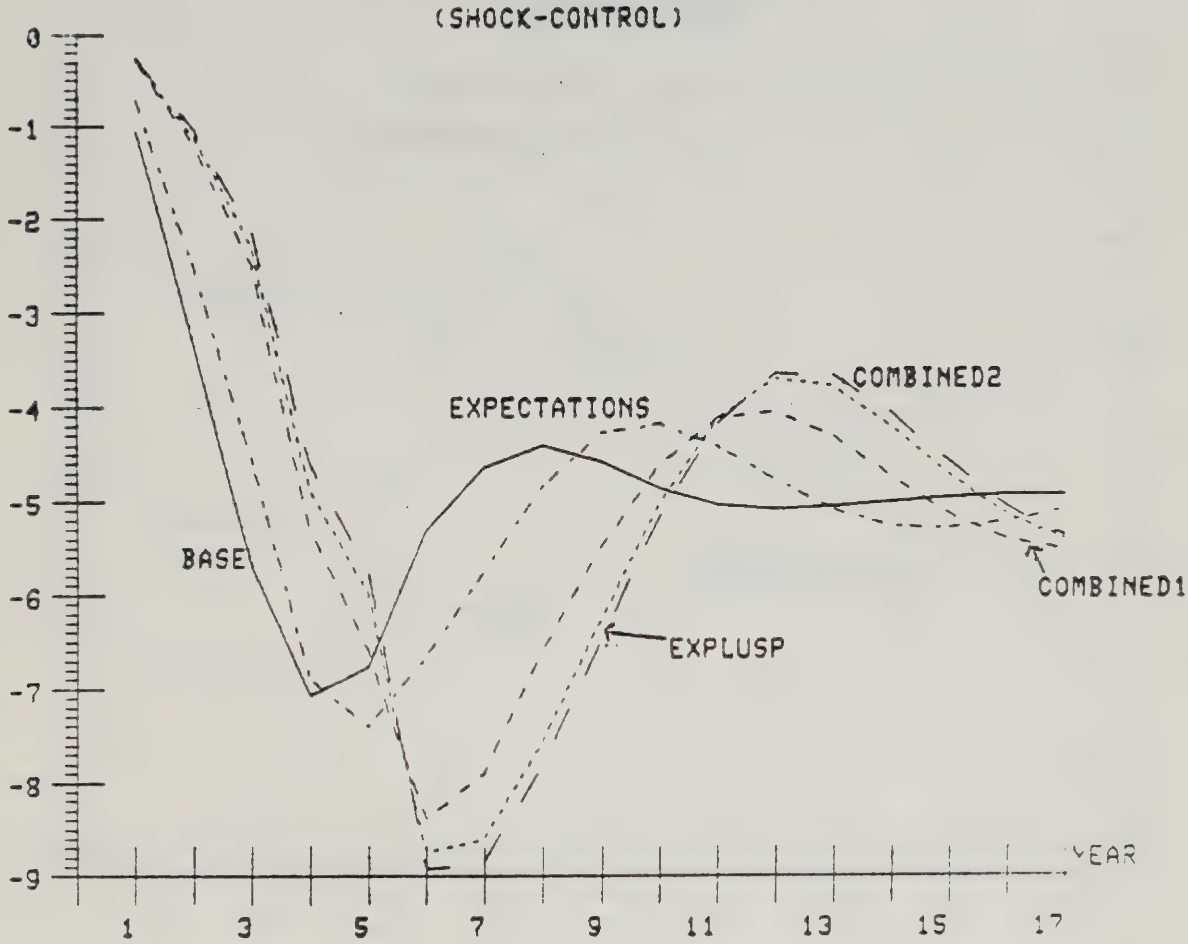


FIGURE 4.3.2

GOVERNMENT BOND RATE
(SHOCK-CONTROL)

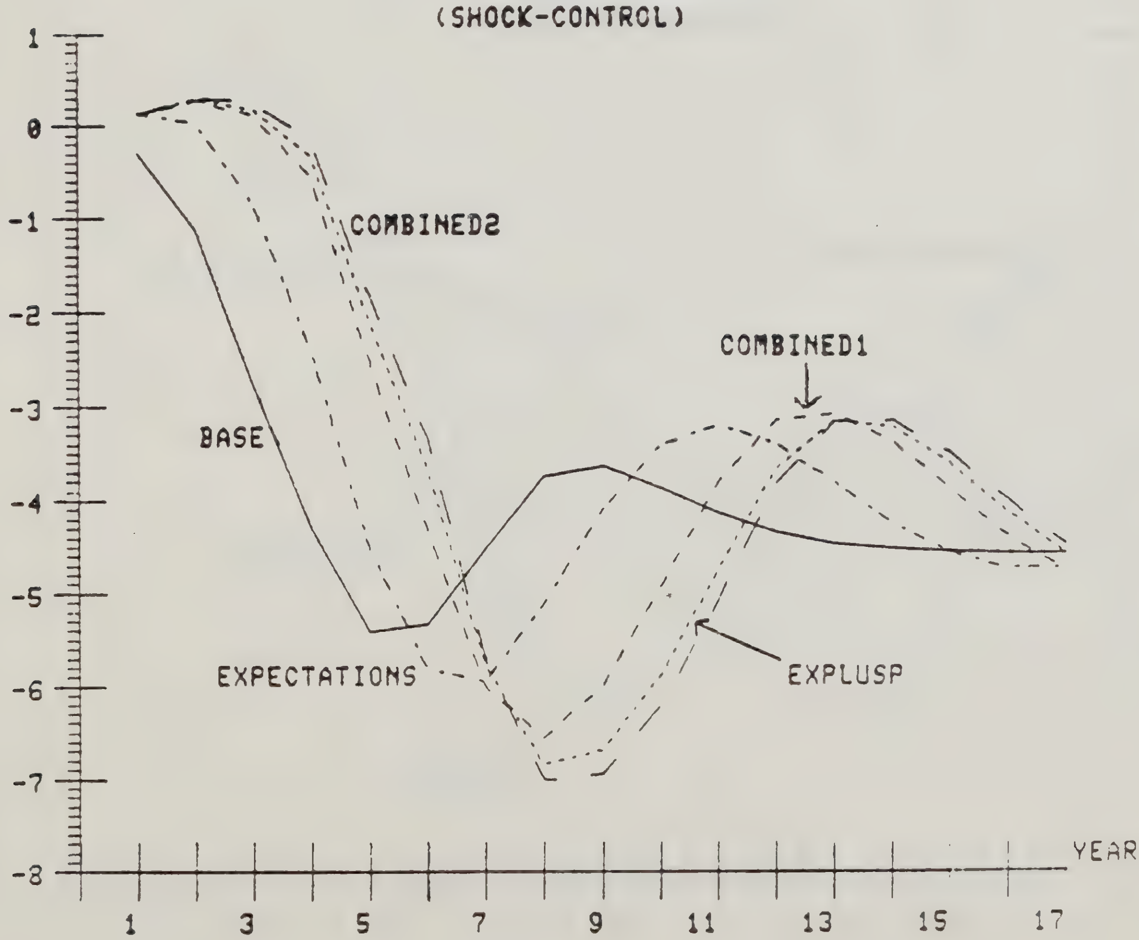


FIGURE 4.3.3

UNEMPLOYMENT RATE
(SHOCK-CONTROL)

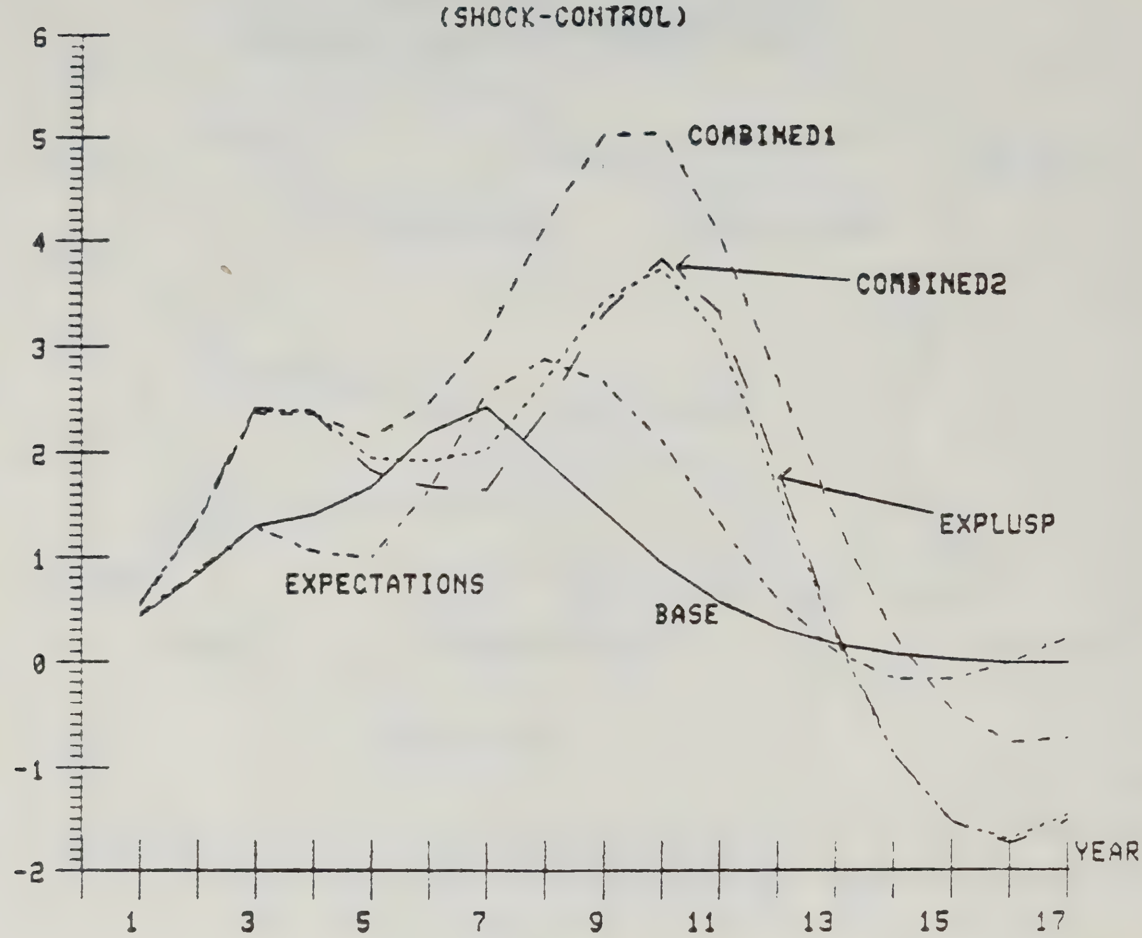


FIGURE 4.3.4

NON-ENERGY OUTPUT
(%SHOCK-CONTROL)

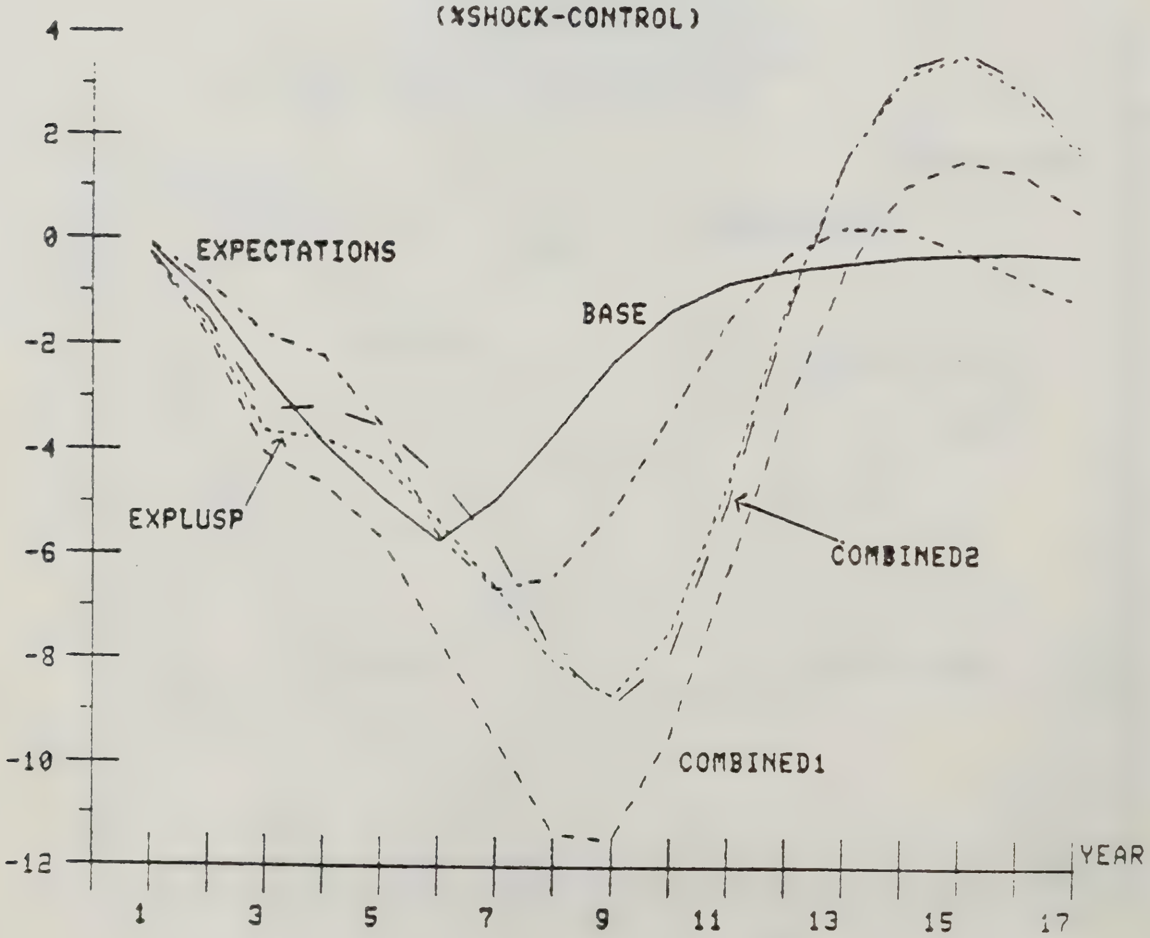
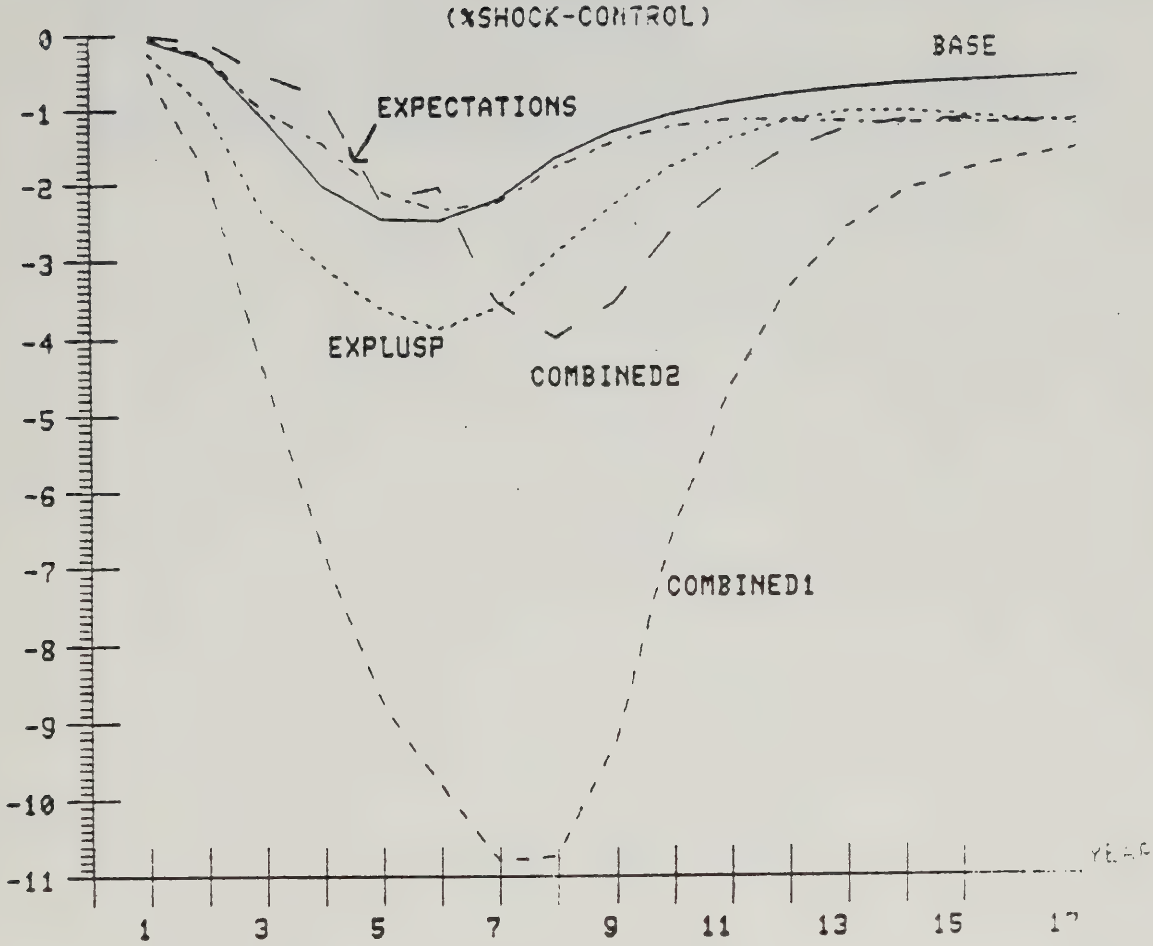


FIGURE 4.3.5

REAL WAGE

(%SHOCK-CONTROL)



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